Dr. Betsy Pugel interviews Dr. Paul Newman for "Straight from the Scientist's Mouth"

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Betsy: Look up at the sky and thank the ozone layer as you tune into another segment of "Straight from the Scientist's Mouth."

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Betsy: Today on "Straight from the Scientist's Mouth," we'll be learning about the ozone layer from Dr. Paul Newman, an atmospheric scientist at NASA's Goddard Space Flight Center.

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Betsy: What is ozone?

Paul: Ozone is a form of oxygen, [which is normally] two oxygen atoms bound together. Ozone is three oxygen atoms bound together.

Betsy: And what's the ozone layer?

Paul: The atmosphere is divided into a series of layers. There's the troposphere, which is down low here. We live in the troposphere, all our weather occurs in the troposphere, all the clouds you see. After you get up to about 32,000 feet or so, it varies around the planet, the atmosphere becomes what we call the stratosphere. There's a boundary there called the tropopause. You get into the stratosphere. Almost all the ozone on our planet is found up in the stratosphere, so if you get up to 70,000 feet or so, you've got a lot of ozone there, probably anywhere from 10 to 50 times more ozone, at least. The concentrations are much higher at 70,000 feet than they are down here at the surface. So the ozone layer is mainly found up in the stratosphere.

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Betsy: Why do living things depend on the ozone layer?

Paul: Well, ozone is a really crucial gas in our atmosphere. And the reason it's crucial is because it absorbs ultraviolet radiation. Now, ultraviolet radiation is, it's light. It's a form of light. It's very intense light. And ultraviolet radiation can break apart molecules that are biologically active, like carbohydrates, proteins, DNA.

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Paul: Most living species can repair the damage done, but sometimes they don't. When, for example, DNA is damaged by UV, and it doesn't repair itself, then it can begin to replicate itself, a damaged form of the DNA is replicating itself, and that's where you get a skin cancer. So, ultraviolet radiation is harmful. Ozone absorbs ultraviolet radiation very effectively. If you go and you look at a wavelength around 250 nanometers, which is a very short wavelength, can't be seen by eye, but ozone absorbs it in a fantastic way. So all the solar radiation at 250 nanometers is absolutely absorbed by ozone. In fact, we did a simple calculation, and it's like one photon hits the Earth every million years at this 250-nanometer range. So ozone is incredibly effective at absorbing ultraviolet radiation. Now, as you move towards the visible radiation, ozone becomes less and less effective. Then you reach a range, which we call UV-B, in which ozone absorbs about 90, 95 percent of the UV radiation, but it doesn't absorb all of it. And that's the radiation that can lead to things like skin cancer. That's what we worry about. We worry about UV-B. We also worry about UV-A, which is just a slightly less energetic form of UV. We also believe that contributes something to skin cancer.

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Betsy: What has contributed to the widening of the ozone hole?

Paul: Well, the cause of the ozone hole is due to manmade compounds, in particular chlorofluorocarbons, [the] trade name is Freons, and Halons, Halons are in fire extinguishers. The chlorofluorocarbons were used -- back in the day they were used in hairsprays and deodorants and so forth. They were then used in car air conditioners. They were used in refrigerators, big large air condition units. They were also used to create foam blowing products, you know, the Styrofoam cups and stuff would be made using CFCs. They were used as cleansing agents, so you could take something, a really greasy auto part, and you could dip it into CFCs, and it would come out, it'd be a nice, sparkling, shiny metal piece. All the grease cleaned right off. It was terrific for that. They were also used in the meter-dose inhalers for asthmatics, you know, little medicine. The delivery gas in those meter-dose inhalers was chlorofluorocarbons. And they were great gases. They're wonderful. They're non-toxic. They're not explosive. They're terrific gases. They don't react with anything. And so you go way back when we were using ammonia in refrigerators, ammonia was explosive and toxic, so CFCs were a great innovation, a great technological achievement. It was only later as we got into the '70s that we began to recognize, in fact, they could produce ozone destruction. In the 1980s when the ozone hole was discovered, we then found that these compounds were extremely destructive, and so the main reason we have the ozone hole is because of these compounds, the chlorofluorocarbons and the Halons and so forth that go in fire extinguishers. So they have a great use, but they also have a side-effect that we didn't realize at first.

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Betsy: How did scientists know to look for it [the ozone hole]?

Paul: We didn't know to look for it. It was a real surprise to all the scientists. We knew that chlorofluorocarbons -- in 1985, we knew that chlorofluorocarbons would produce some ozone destruction. What we didn't recognize was that there was an interesting form of chemical reactions that occur over Antarctica and over the arctic also, where you get extremely cold conditions in the stratosphere. [In those areas] form these beautiful clouds called polar stratospheric clouds.

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Paul: They have kind of a mother of pearl characteristic. They're just beautiful. Beautiful coloring and patterns, in these polar stratospheric clouds.

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Paul: Well, what happens is a particular chemistry occurs on the surfaces of the cloud particles that releases chlorine from a non-reactive form into a very ozone-destructive form. And so, it gets very cold over Antarctica in the middle of winter. You form these polar stratospheric clouds. Because we have chlorofluorocarbons, or we have the chlorine from the chlorofluorocarbons over Antarctica, these polar stratospheric clouds enable this very fast ozone-destruction reaction, and so you get a big ozone hole in October. You also get ozone losses in the Northern Hemisphere in March. The good thing about the Northern Hemisphere, though, is the Northern Hemisphere's stratosphere is much, much warmer than the Antarctic stratosphere, so the losses are smaller. Nevertheless, we do see these ozone losses every year over Antarctica, as well as the arctic. They're less extensive, it's not as bad over the arctic as it is over the Antarctic, but nevertheless, we see ozone losses every year over the [arctic and Antarctic].

Betsy: Does the hole regenerate itself over time?

Paul: Yeah, you can think of -- the ozone hole is a removal of ozone over Antarctica, and you can think of -- if you take a bucket of water, and you scoop out a big glass right in the middle of that bucket of water, and then you lift it out, the water level sinks all over the bucket. That's the same thing [that] happens with the Antarctic ozone hole. You remove a whole bunch of ozone, and then as it mixes around the hemisphere, ozone gets lowered everywhere in the Southern Hemisphere. So, even though it occurs over Antarctica, you tend to lower ozone levels over places like New Zealand and Australia, because of the ozone hole and the mixing that occurs as you go from the winter circulation to that summer circulation.

Betsy: How long do you think it will take for the ozone hole to recover over time, other than the seasonal variations?

Paul: The good part of the story about the ozone hole is that the gases that cause ozone loss have been regulated. By international agreements, countries got together and they agreed that this was a real problem, ozone depletion was a real problem. They negotiated a treaty to regulate these gases, and in fact production of the chlorofluorocarbons has been stopped. That's the good part of the story.

Betsy: This is the Montreal Protocol?

Paul: This is the Montreal Protocol. The unfortunate part of the story, as I mentioned, chlorofluorocarbons are very non-reactive. They have very, very long lifetimes in our atmosphere. Chlorofluorocarbon-12, which was highly used in car air conditioners, has a lifetime of about 100 years, so just to see -- if you released a pound of CFC-12 into the atmosphere right now, and we came back 100 years from now, there'd still be about a quarter of that gas still in the atmosphere, so about 75 percent would have been removed over that 100 years. These gases have very long lifetimes in the atmosphere. So it didn't take long for the ozone hole to form. We began to see it in the '80s, and by the 2000s, or mid-1990s, it was extremely large, getting up to the size of 25 million square kilometers, but it's going to go away very slowly because chlorofluorocarbons come out of the atmosphere very slowly. We don't think it's going to be recovered to the 1980 levels until about 2065, 2070, so another 60 years or so before we see it back to the levels we had in the 1980s. It'll take a while.

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Betsy: What can our listeners do to support the recovery, or at least not do further [harm] to the ozone [layer]?

Jeff: Well, there's a few things that people can do. I think the first and foremost is, if you're replacing your air conditioner, take a look at what kind of gas they're putting into it. Many of the chlorofluorocarbons were replaced with what are called HCFCs, hydrochlorofluorocarbons. HCFCs are much less destructive than CFCs. Nevertheless, they do produce a little bit of destruction. There are new gases out now that have no chlorine or bromine in them, and those can be used in the new air conditioners. The first thing I would do is, people should take a look at -- if they're going to replace your air conditioner, take a look at it and see what kind of gas is going into it. See if it is an ozone-friendly gas or not. A second thing you can do is, when you recycle your refrigerator, old refrigerators have CFCs in them. See if you can find -- there are a few of these recycling outfits out there, who will come and they will remove the CFCs from the unit and recycle those CFCs. We still need CFCs in a lot of places, and instead of venting them out into the atmosphere where they can destroy things, see if you can recycle it. So that's the second thing you can do. The third thing that you can do is of course, I think, pay attention to the issues. These are issues that involve people. We scientists, we try to stay a little bit beyond the fray. We're here to answer scientific questions: what to do, how's it happening, are there things that we can do about it? But politically, scientists try to be non-partisan. That is, we're here to answer questions. We're not here to provide a platform for people to stand on. But people don't have that restriction. They can act on the answers we provide.

Betsy: Well, thank you very much.

Jeff: OK.

Betsy: Appreciate it.

Jeff: No problem.

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Betsy: Thank you for joining us for another segment of "Straight from the Scientist's Mouth." You can check out the link to our show on the Burning Man Web site [. You can also find information at www.nasa.gov/goddard. G-O-D-D-A-R-D.

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